Research Note 85-105

TASK AND TRAINING REQUIREMENTS ANALYSIS FOR ADVANCED ARMY HELICOPTERS: Final Summary Report

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A series of interrelated analytical tasks was completed in order to support the training development of the AHIP scout, AH-64, and AH-1S(MC) helicopters. The tasks were: (1) mission profile analysis, (2) time series analysis, (3) allocation of functions, (4) detailed task analysis, and (5) training requirements development.

Each task resulted in an individual set of end products which provide required information in themselves and which formed the basis of later tasks.

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20. Abstract (continued)

Cont. The need for coordination training, both within helicopter team training courses and between team training courses, and for training in problem solving are pointed out, along with the possible need for selection standards methods which are based on the crew members' ability to solve problems while under high levels of collateral perceptual-motor load.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

I. INTRODUCTION

Army helicopter employment, in the past decade, has been the subject of considerable change including increased emphasis on terrain flight, multiaircraft teams, flight during marginal weather conditions, and night operations. Hand-in-glove with the doctrinal changes are substantial modifications in flight, avionics, and weapon systems. The equipment system changes, driven by the advanced doctrinal emphasis, are necessary in order to meet the demands of new missions and tactics.

The combination and interaction of doctrinal changes and new equipment systems has direct implications for training. Demands for new skills and knowledges have been created. There have also been corresponding increases in the operator's loads, both intellective and perceptual-motor.

The development of an effective manning system for the advanced helicopters requires a thorough front-end analysis designed to provide timely information on task functions, crew/team coordination requirements, intellective requirements, and training requirements.

To this end, a series of interrelated tasks was performed: (1) scenario development and mission profile analysis (Applied Psychological Services, 1982a), (2) time series analysis (Applied Psychological Services, 1982b,c,d), (3) allocation of functions (Applied Psychological Services, 1982e), (4) detailed task analyses for the AHIP scout helicopter, the AH-64, and the AH-1S(MC), (Applied Psychological Services, 1982f,g,h) and (5) training requirements development (Madden, Pfeiffer, and Siegel, 1983).

The details of each of the study tasks are presented in the individually referenced reports. The present report summarizes the total program.

The analysis which led to the individual requirements for advanced combat missions in emerging Army helicopters proceeded in an orderly fashion. The entire undertaking was organized according to principles derived from general systems theory. The various tasks represented successive stages in the systematic development of program information. The general flow of work across tasks is illustrated in Figure 1. As indicated in Figure 1, the output from each task served as the input into the next task(s). In this way, program information developed at each stage formed the basis for the analyses at the next stage. The final box of Figure 1, "evaluation," was not considered within the present work. It is included in the figure to suggest the feedback loop essential to any front-end analysis.

II. METHOD

A summary of the details of the methods and results of each step of the work is presented categorically below.

Task 1--Mission Profiles

An analysis of the operational requirements is the necessary starting point for a system analysis. During Task 1, mission profile development, the missions and systems lists employed in later study steps were identified for the AHIP, the AH-64, and the AH-1S(MC). To select missions appropriate to current and projected Army operations and tactics, a generalized scenario was developed. Based on the scenario, five missions were identified as a basis for subsequent analyses:

AHIP in conjunction with an AH-64 on an attack against a predesignated target

AHIP in conjunction with an AH-1S(MC) on an attack against a predesignated target

AHIP in conjunction with an AH-64 on a reconnaissance/screening mission

AHIP in conjunction with an AH-1S(MC) on a reconnaissance/screening mission

AHIP on an adjust indirect artillery fire mission (FAAO).

For analytical purposes, each mission was divided into phases, (e.g., enroute, reconnaissance, target servicing) and the phases were divided into meaningful segments (e.g., low level flight, contour flight, evade threat fire).

The equipment systems used by the crew members to perform the various mission activities were identified using the specifications for each helicopter. Eleven systems were analytically differentiated for each aircraft. The exact collection and specific types of equipment varied across aircraft but each equipment system in one helicopter generally had a functional equivalent in the other helicopters. The systems were:

1. flight control system
2. flight instruments
3. external visual field
4. integrated flight information system
5. systems instruments
6. internal communication system

7. external communication system

8. navigation system

9. survivability devices

10. sighting devices

11. target engagement devices.

The actual mission profile analyses consisted of assessing changes in equipment system use across the phases and segments of each mission. The analyses included identification of equipment systems employed, time (duration) of use, and demand placed on the user during use for each helicopter/mission/phase/segment. The analyses yielded five mission profile analyses. These are presented in Appendix A as Figures A-1 through A-5. The profiles were of sufficient detail to allow subsequent identification of all equipment related tasks, temporal sequences, and overlaps among tasks.

Task 2--Time Series Analyses

The Task 2 time series analyses were concerned with identifying and describing the activities performed in each mission segment. The analyses were executed within the framework of the mission/phases/segments systems established in Task 1. Accordingly, the mission profile analytic data were the inputs into the Task 2 time series analyses.

The activities of crew members in each aircraft were analyzed to assess: (1) the inputs from each equipment system needed to drive the activities, (2) the required outputs, and (3) the operator-equipment functional interactions. Within the transformations of inputs into outputs, the type of information (qualitative, quantitative, or check) processed and the amount and the difficulty of the processing were identified.

Describing and specifying the functional interactions was achieved at the equipment subsystem level. Each equipment system, identified in the Task 1 analysis, was broken into its component subsystems, e.g., one component of the navigation system in the attack aircraft was the doppler display and controls. Describing the task(s) associated with each subsystem in each mission segment specified the operator-equipment functional interaction.

During the course of the analysis, the "criticality" of each operator activity and the "delay tolerance" of the activity were also scaled. The result was a detailed compilation for each operator activity in each aircraft/mission/segment of:

1. equipment systems and subsystems involved

2. location of each subsystem (P = pilot's station, C = copilot's or observer's station, B = both stations)

3. the purpose of the operator functional interaction with each subsystem

4. who interacts with each subsystem (P = pilot, C = copilot or observer, B = both)

5. the type of operator activity (M = motor, V = visual, A = auditory, S = speech)

6. the type of information processed (QT = quantitative, QA = qualitative, CK = check)

7. the amount and the difficulty of the mental activity involved in completing the operator activity (each scaled from 1 to 7)

8. the amount and the difficulty of the motor activity involved in completing the operator activity (each scaled from 1 to 7)

9. the delay tolerance for the operator activity (each scaled from 1 to 5)

10. the criticality of the operator activity (each scaled from 1 to 5)

11. comments primarily in terms of activity sequence, which elaborated or qualified the information presented.

Items 7, 8, 9, and 10 above, were assessed for both night and day operations.

The analyses were completed by a team composed of a human factors psychologist with military flight experience, an experimental psychologist, a pilot with experience in attack helicopters, and a pilot currently rated in scout helicopters. Inter-rater agreement was attained by requiring that all judgements/assessments/classifications made by a psychologist be reviewed by a helicopter pilot, and that all those made by helicopter pilots be reviewed by a psychologist. Any discrepancies between the initial analyst and the reviewer were resolved in a meeting of the entire team.*

Accordingly, Task 2 elaborated on the mission profiles to provide statements of the tasks performed by each crew member during each segment of the Task 1 analyses along with an analysis of each task.

Figure B-1 in Appendix B shows a sample of the results. While the format of these analyses was very much the same for all three aircraft under study, the systems varied.

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* This team completed all of the analyses of the series described throughout this report.

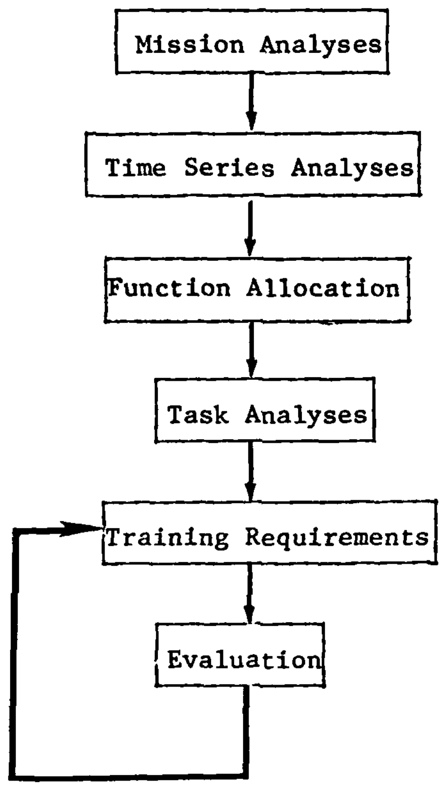

Figure 1. Flow of program information.

Task 3--Allocation of Functions

The results of Task 2 led to an examination of the division of labor across crew members within the three helicopters and of the demands placed on them by the equipment subsystems. In Task 3, an analysis was completed with an emphasis on reducing the load on all crew members, and on equalizing the load across crew members. The missions and segments included in these analyses are presented in Table 1.

The crew member functions used in the allocation of function analyses were derived from the Task 1 analyses. This involved specifying the functional use of each system, e.g., system 1, flight control, became function 1, control flight with cyclic, collective, and pedals. The derivation of the functions was performed for each aircraft so that differences in equipment subsystems among aircraft was reflected in differences in functions. Eleven functions were derived for each aircraft.

The analysis progressed in two steps: (1) allocation between crew and equipment, and (2) allocation between crew members of tasks not allocated to the equipment. In each step, a set of rules was rationally applied across aircrafts, missions, and segments.

Throughout both parts of the function allocation, the analysis was at the level of the selected segment by function. Thus, the same function could be assigned differentially between various segments and missions.

To derive the allocation rules, available literature (e.g., Hutchingson, 1981; DeGreene, 1970; Lyman and Fogel, 1961) was consulted to provide an initial set of concepts for allocation of functions to either the equipment or the operator in a system. This conceptualization was extended, adapted, and integrated into a set of rules for the allocation of functions between crew members and equipment:

1. Where the process is dependent upon maximum flexibility, assign it to the aircrew; e.g., NOE flight.

2. Where the process is dependent upon complex procedures requiring a large number of differentiations or integrations, assign it to the equipment; e.g., estimating target coordinates.

3. Where the process is dependent upon infallible memory with its precise source accurately tagged (and ignoring display potential), assign it to the equipment; e.g., weapons available/expended.

4. Where the activity involves the consideration of a situational context in which the weightings of the factors involved vary in accordance with the context, assign it to the aircrew; e.g., selecting priority targets.

Table 1

Flight Segments Contained in Each Mission

Segments	Mission a*	b	c	d	e
Takeoff	x	x	x	x	x
Enroute/Return					
Low Level	x	x	x	x	x
Contour	x	x	x	x	x
NOE	x	x	x	x	x
Traveling			x	x	
Overwatch	x	x	x	x	
Bounding Overwatch			x	x	
Coordinate Tactical Instrument Plan			x	x	
Tactical Instruments Enroute			x	x	
Precision Approach Radar			x	x	
Enemy Engagement					
Locate/Identify Threats	x	x	x	x	x
Select Fire Position/NOE	x	x	x	x	
Handoff Point Weapon	x	x	x	x	
Handoff Artillery					x
Adjust Fire/Security	x	x	x	x	
Reposition	x	x	x	x	
Mask/Unmask		x		x	x
Engage Target	x	x	x	x	
Assess Damage	x	x			x
Evade Threat Radar/Fire			x	x	
Landing	x	x	x	x	x
Refuel (Hot)/Rearm	x	x	x	x	x

a = AHIP/AH-64 attack
b = AHIP/AH-1S(MC) attack
c = AHIP/AH-64 reconnaissance/screening
d = AHIP/AH-1S(MC) reconnaissance/screening
e = AHIP/indirect fire (FAAO)

5. Where the activity involves contextless deductive reasoning, assign it to the equipment; e.g., predicting altitude.

6. Where the activity involves inductive reasoning of a straightforward nature, assign it to the equipment; e.g., time to target.

7. Where the activity couples active hypothesis formulation with inductive reasoning, assign it to the aircrew; e.g., selecting priority targets.

8. Where the activity involves prediction of the future and if the weightings of the variables involved are known, assign it to equipment; e.g., navigation.

9. Where the activity is a low probability event not feasible for automation because of the number of possible events, assign it to the aircrew; e.g., selecting evasive route.

10. Where the process is dependent on very low absolute threshold sensitivity, assign it to the aircrew; e.g., detecting targets in noise.

11. When the process depends on precise tracking over limited error ranges for extended duration, assign it to equipment; e.g., target tracking.

In some cases, it was believed possible to modify extant equipment or to develop new equipment to achieve the allocation. Examples of such equipment modifications or developments are: (1) data or message sending device, (2) hover hold device, (3) auto pilot, (4) electrocutaneous warning device, and (5) night vision device (improved). In such cases and if the rules so indicated, the function was allocated to equipment.

Once functions were assigned to the aircrew, a second set of rules was used to allocate them to the pilot or copilot/gunner or observer:

1. Allocate associated functions to the same crew member.

2. Allocate "command" functions to the pilot.

3. Make allocations on an optimal allocation basis and not necessarily on a current practice basis.

4. Assign integration and coordination functions to the pilot.

5. Minimize instances of overloading either crew member.

6. Avoid unnecessary fatigue of either crew member.

In making the final between crew member allocations, the intellective and the perceptual-motor load estimates derived during the performance of Task 2 were used to assess the reasonableness of the suggested assignments and reassignments.

As a result, Task 3 provided statements about whether or not each action in the time series analyses of Task 2 is best performed by the aircrew or the equipment and, if allocated to the aircrew, which crew member. The consequences of the optimum allocation are summarized in Table 2. The table indicates that load reductions ranging between 40 and 50 percent are possible by mere reallocation.

Task 4--Task Analysis

In Task 4, detailed task analyses were completed. Each task identified in the Task 2 time series analysis was analyzed to the level of the activity (structurally task, subtask, activity). The analyses decomposed every task performed by the pilot and or copilot/gunner or observer to a detailed level of analyses. The results of the task analyses were used in Task 5 for deriving criterion referenced training objectives, determining training device requirements, developing performance evaluation methods, and for projecting the success potential of trainees on various tasks. Figure 2 presents examples of the task analytic materials. The format of these analyses was very much the same for all three of the helicopters under study. Each compendium presented for each major task:

° a list of subtasks involved in completing each task

° a list of the activities involved in completing the subtasks

° for each activity:

  displays/controls used
  indication of response adequacy
  effect of error
  quantitative scaling of error impact
  type of intellective activity involved

Table 2

Frequency of Moderate to High Loads* Before and After Optimum Allocation and Percentage Reduction ($\Delta\%$)

		Attack			Reconnaissance			FAAO		
		Before	After	$\Delta\%$	Before	After	$\Delta\%$	Before	After	$\Delta\%$
AHIP	Pilot	120	68	43	121	71	41	101	59	42
	Observer	93	52	44	89	52	42	80	49	39
AH-64	Pilot	148	74	50	166	89	46			
	Copilot	131	64	51	138	72	48			
AH-1S(MC)	Pilot	139	76	45	153	84	45			
	Copilot	132	77	42	134	75	44			

*Loads scaled 4, 5, 6, or 7

TASK ANALYSIS

Function No. 1.0 Function Name Control Flight with Cyclic, Collective, and Pedals Page 1-a of 4

Task No. 1A.1 Task Name FLY LOW LEVEL, VMC

PILOT'S SUBTASK AND NUMBER	COPILOT'S SUBTASK AND NUMBER	ACTIVITIES	DISPLAY(S)/ CONTROL(S)	RESPONSE ADEQUACY INDICATION	ERROR	
					POTENTIAL	IMPACT
1A.1.1 Control aircraft		Route orientation	External visual	Visual feedback	Damage aircraft	4
		Hold airspeed	Cyclic, collective, pedals	Airspeed 10 KIAS	Poor efficiency of aircraft	2
		Follow desired course	Cyclic	Arrive at predetermined checkpoints 2 minutes of ETA	Miss destination	3
		Hold altitude	Collective	Altitude 25 feet	Expose aircraft	3
		Hold trim	Pedals	Ball within limits	Poor efficiency of aircraft	2

Figure 2. An example of the first half of the task analysis worksheet

TASK ANALYSIS (cont.)

Function No. 1.0 Function Name Control Flight with Cyclic, Collective, and Pedals Page 1-b of 4

Task No. 1A.1 Task Name FLY LOW LEVEL, VMC

Slightly 1 — Rather 2 — Quite 3 — Very 4 — Extremely 5

INTELLECTIVE														PERCEPTUAL MOTOR					
CONTENTS			OPERATIONS				PRODUCTS					AMOUNT SCALE VALUE(A)	DIFFICULTY SCALE VALUE(D)	INTELLECTIVE LOAD VALUE (AxD)	AMOUNT SCALE VALUE(A)	DIFFICULTY SCALE VALUE(D)	PERCEPTUAL MOTOR LOAD VALUE(AxD)	TIME (SEC)	TRAINING REQUIREMENTS	NOTES
F	SY	SM	C	M	CP	E	U	CI	R	T	I									
X			X						X			2 (3)	1 (1)	2 (3)						Poor visibility load estimates in parenthesis when different from good visibility load estimates
															1	1	1			
															2	2	4			
															2	2	4			
															1	1	1			

Figure 2. (cont.) An example of the second part of the task analysis worksheet

quantitative scaling of amount of intellective effort
quantitative scaling of difficulty of intellective effort
total intellective load (amount x difficulty)
quantitative scaling of amount of perceptual-motor effort
quantitative scaling of difficulty of perceptual-motor effort
total perceptual motor-load (amount x difficulty)
time estimation of the activity's mean duration
notes--comments (where applicable)

The assessment of the intellective and the perceptual-motor effort involved in completing each activity was dichotomous. If an activity was considered to be primarily intellective in nature, it was classified as such and assessed for the amount and difficulty of the intellective effort involved. Similarly, activities considered to be primarily perceptual-motor in nature were assessed for the amount and difficulty of the perceptual-motor effort.

All intellectual activity was also classified in terms of the activity's content, operations, and products as originally formulated by Guilford (1967). Content referred to the type of information processed and was categorized as:

° Figural (F)
° Symbolic (SY)
° Semantic (SM).

Operations referred to the type of intellective activity involved and were classified as:

° Cognition (C)
° Memory (M)
° Convergent Production (CP)
° Evaluation (E).

Products referred to output from the interaction of the operation with the content. Products were categorized as:

° Unit (U)
° Classes (CL)
° Relations (R)
° Transformations (T)
° Implications (I).

A major result of this intellective analysis was the identification of the intellective categories most heavily involved in helicopter aircrew functions. Tables C-1 and C-2 (Appendix C) present the most highly

scaled intellective categories of AHIP pilots and observers while Tables C-3 through C-6 present the most highly scaled intellective categories of AH-64 and AH-1S(MC) pilots and copilots. The intellective operations most heavily demanded can be seen in Table 3.

Task 5--Training Requirements Specification

Task 5, training requirements specification, was organized around the functions defined in Task 3 and utilized the task analytic assessments of Task 4. The Task 5 work was executed in four parts. Initially, transition training requirements were defined for the crew members of each aircraft of concern. Training requirements are statements of what a trainee must be able to do or know as a result of training and there was a one-for-one correspondence between the Task 4 task listings and the description of the training requirements. Second, training requirements that transition trainees would be expected to have previously achieved were eliminated or "filtered" from further consideration. Next, training objectives, reflecting the degree of proficiency to be achieved in the transition training and criterion objectives (operationally defined measures of performance) were developed. The final concern of Task 5 was identification of the most appropriate training method for training on the required tasks so that performance will be at the required criterion levels. In this regard, preferred training methodologies were isolated and training sequences were systematically developed.

The following definitions were employed:

Behavior: a global statement of crew member's activity during the performance of a subtask

Training requirement: skills and knowledges crew members must learn

Criterion measure: standards of performance to be used within the training context for assessing student mastery

Enabling knowledge: knowledge necessary prior to training on a particular function

Type of learning: classification of the learning required to achieve a given training requirement (see discussion below)

Training technique: a procedure for implementing the learning type

Fidelity: estimated degree of realism required in any required training device

Table 3

Frequency of Most Heavily Demanded Intellective Operations Across Functions for Each Helicopter Type

Pilot's Intellective Operations	---- Aircraft ----		
	AHIP	AH-64	AH-1S(MC)
Evaluation	8	16	19
Cognition	9	10	10
Convergent Production	3	5	5
Memory	2	2	1

Copilot's /observer's Intellective Operations	---- Aircraft ----		
	AHIP	AH-64	AH-1S(MC)
Evaluation	12	16	16
Cognition	5	10	4
Convergent Production	7	8	6
Memory	0	0	0

Training time: estimated time for average trainee to achieve mastery relative to a criterion objective

Crew/team coordination requirements: statement of crew or team training requirements.

In order to relate each learning type to the preferred type of training, a systematic set of linkage rules was followed. The linkages are shown in Table 4, in which the different types of learning are shown along with the training type most suitable to each learning type. The learning types presented in the first column of Table 4 are defined below:

Signal learning: recognition of a signal, a condition, or a state

Stimulus-response: performance of a specific action when a given condition or set of conditions occur. This involves recognition of the stimulus situation and demonstration of the appropriate response or set of responses

Chaining: performance of a set or a pattern of alternate actions in response to a given condition or set of conditions

Principle learning: transforming system or equipment data to another form so that it can be applied to a problem or a set of problems

Concept formation: learning why a given condition or set of conditions require a given set of responses

Problem solving: learning to recognize the implications of various courses of action.

The major results of task 5 were training summary tables. One table was composed for each helicopter of concern. Each table listed crew member functions, the original number of tasks within each function, the number of remaining tasks after tasks eliminated from transition training were "filtered," suggested training method, estimated hours for an average trainee to achieve mastery, the optimal training sequence, and a statement of crew/team coordination requirements. Tables 5, 6 and 7 present the training summaries for the AHIP, AH-64, and AH-1S(MC), respectively.

The training is designed to provide an aircrew, skilled in helicopter operation, with the basic knowledge and skill for transitioning into the AHIP, AH-64, or AH-1S(MC). The Task 5 report (Madden, Pfeiffer, & Siegel, 1983) also presented an initial concept of a synthetic trainer which was conceived to support proficiency development in both the

Table 4

Preferred Type of Training for Each Learning Type

Learning Type	Preferred Training Type
Signal	Part Task
Stimulus-Response	Part Task/Procedural
Chaining	Whole Task/Procedural
Principle	Whole Task
Concept Formation	Whole Task
Problem Solving	Whole Task

Table 5

AHIP Transition Training Summary

Function	Original No. of Tasks	Remaining Tasks	Training Method	Training Hours Observer	Training Hours Pilot	Training Sequence	Crew/Team Coordination
1. Control Flight with Cyclic, Collective, and Pedals	9	6	Whole task/ procedural	0	2	3	Low
2. Read/Monitor Secondary Flight Instruments	3	3	Part task/ procedural	2	2	3	Low
3. Environmental Orientation	10	10	Part task/ procedural	10	10	7	Moderate
4. Use Pilot's MFD/Controls	6	6	Part task/ procedural	0	5	2	Low
5. Use Observer's MFD/ Controls	39	39	Whole task	15	15	4	High
6. Monitor/Read Systems Instruments	3	3	Part task/ procedural	2	2	1	Low
7. Intracrew Communication	12	10	Whole task/ procedural	5	5	5	High
8. External Communication	7	6	Whole task/ procedural	5	5	6	High
9. Use Survivability Devices	2	2	Whole task/ part task	2	2	9	Moderate
11. Use MLMS Controls	1	1	Whole task/ procedural	2	2	10	Moderate

Table 6

AH-64 Transition Training Summary

Function	Original No. of Tasks	Remaining Tasks	Training Method	Training Hours CP/G	Training Hours Pilot	Training Sequence	Crew/Team Coordination
1. Control Flight with Cyclic, Collective, and Pedals	9	6	Whole task/ procedural	2	2	8	Low
2. Read/Monitor Flight, Condition and Warning Instruments	4	4	Part task/ procedural	2	2	2	Low
3. Environmental Orientation	10	10	Part task/ procedural	8	8	7	Moderate
4. Use Integrated Flight Navigation Displays, Maps	6	6	Part task/ procedural	2	2	3	Low
5. Monitor/Read Systems Instruments	3	3	Part task/ procedural	2	2	1	Low
6. Intracrew Communication	14	12	Whole task/ procedural	5	5	5	High
7. External Communication	14	13	Whole task/ procedural	5	5	6	High
8. Use Navigation System to Fly a Course	13	13	Whole task	8	8	4	High
9. Use Survivability Devices	4	4	Part task/ whole task	3	3	9	Moderate
10. Use TADS/PNVS Displays for Threat Identification, Detection, etc	26	26	Whole task/ procedural	8	8	10	High
11. Use Devices and Controls to Select/Engage Target	7	7	Whole task/ procedural	5	5	11	High

Table 7

AH-1S(MC) Transition Training Summary

Function	Original No. of Tasks	Remaining Tasks	Training Method	Training Hours CP/G	Training Hours Pilot	Training Sequence	Crew/Team Coordination
1. Control Flight with Cyclic, Collective, and Pedals	9	6	Whole task/ procedural	2	2	8	Low
2. Read/Monitor Primary Flight Instruments	3	3	Part task/ procedural	2	2	2	Low
3. Environmental Orientation	10	10	Part task/ procedural	8	8	7	Moderate
4. Use Integrated Flight Navigation Displays, Maps	6	6	Part task/ procedural	2	2	3	Low
5. Read/Monitor Caution, Warning and Sequence Instruments	3	3	Part task/ procedural	2	2	1	Low
6. Intracrew Communications	12	10	Whole task/ procedural	5	5	5	High
7. External Communications	15	14	Whole task/ procedural	5	5	6	High
8. Use Navigations Systems to Fly a Course	14	14	Whole task	8	8	4	High
9. Use Survivability Devices	2	2	Whole task/ part task	2	2	9	Moderate
10. Use Visual Sighting Devices for Threat Identification, Detection	11	11	Whole task/ procedural	6	6	10	Moderate
11. Use Devices and Controls to Sense, Engage Target	3	3	Whole task/ procedural	4	4	11	High

system operation and problem solving aspects of helicopter combat mission operations.

The system, called the Integrated Transition Training System (ITTS), and shown in Figure 3, is based on the premise that a trainer which appropriately allows for the inclusion of principles of learning in the training situation will more fully support the training than one of higher fidelity (i.e., a full scale flight simulator) but less amenable to the inclusion of learning principles.

The ITTS possesses at least the following advantages:

1. The hardware system can accommodate individual and crew training for the AHIP, AH-64, and AH-1S(MC). Software drives the system so that displays appropriate to each aircraft type can be presented on trainee terminals, depending on the individual/crew to be trained.

2. Similarly, the system can be employed to train scout-attack helicopter teams. Such team training is believed essential to the successful completion of a number of missions.

3. Training economy is introduced by accommodating up to eight trainees at any one time. Each trainee may be trained at his own pace. Moreover, four crews (eight trainees) may be accommodated simultaneously.

4. The synthetic trainer accommodates team training and any mix of aircraft type can be simulated when team training is presented.

5. The ITTS can accommodate both procedural training and problem solution training.

6. The trainer fully takes advantage of principles of learning such as prompts, feedback of performance adequacy, and adaptive training.

System Description

The ITTS contains four major components, (1) an instructor station, (2) individual trainee stations, (3) audio-visual support media, and (4) computer subsystem. Each major component serves a unique purpose. Direct communication between the various stations is included and various communication links can be enabled or disabled at instructor option.

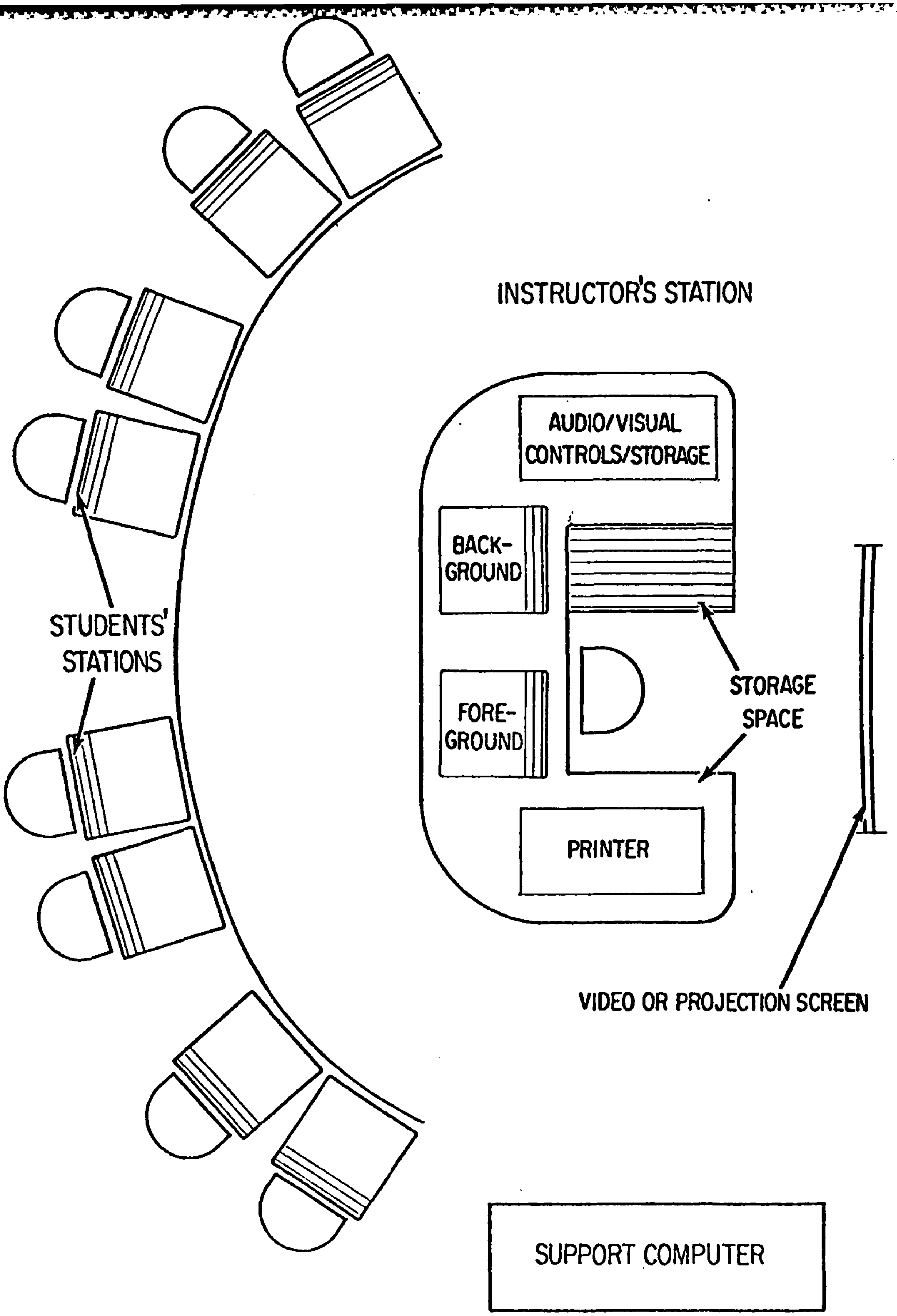

Figure 3 Schematic of integrated transition training system.

Instructor Station

The instructor station is interactive with direct links to the trainee stations, the support computer, relevant data bases, and the audio-visual support system. The instructor's station possesses two terminals and independent keyboards for each. One terminal is used in foreground mode and the other is used for background mode activities. The capability to monitor and interact in both the foreground and the background modes enhances the system's flexibility.

In the foreground mode the instructor can:

- monitor information presented on the trainee terminals
- select a specific student's display to monitor
- allow input on any selected display to be monitored by selected trainee(s)
- enter problems and situations for a solution
- "freeze" action
- advance a problem or revert back to an earlier point in a scenario
- modify problems to meet contingencies
- perform criterion attainment assessments.

This capability allows the instructor to make specific points or develop ideas while, at the same time, standardized training is maintained.

The background mode allows independent assessment of activities including:

- individual progress toward attaining criterion objectives, i.e., historical data on previous criterion assessments
- each trainee's solution to an ongoing training problem as it is recorded by the trainee
- number of students completing a particular lesson plan
- progress within any lesson plan
- any outstanding trainees in current lesson (both superior and inferior)
- each student's progress record.

Accordingly, the background mode allows the instructor to assess the progress of each trainee without disrupting foreground activities. The student progress data base is continuously accessible and updated. Accordingly, the need for individual, crew, or team remedial training can be quickly identified.

Audio-Visual Subsystem

Functionally integrated with the instructor station is the audio-visual support subsystem. This subsystem includes a variety of aids, such as, slide-tape presentation, video disc presentations, slides, and tutorial materials. The mix of audio-visual aids for any lesson plan varies and, at instructor option, may be projected on any one or all of the trainee station screens or on the large video projection screen.

Trainee Stations

Each of eight trainee stations is interactive and adaptive. Each station contains a CRT, a keyboard, and a set of dedicated keys. Each trainee station is designed to accept a variety of hand and foot controls and these can be integrated as modular units. The controls are specific to the aircraft and the crew station being trained. Such items are included as a cyclic, collective, pedals, and tracking controls. The station is interfaced to accept the modular units. Interfaces can be seen in Figure 10.

Adaptability

One of the more useful aspects of the ITTS is its adaptability to training individuals, crews, and scout-attack teams.

Training in the ITTS for individual tasks is straight forward; the trainees use their own terminals independently. In training for tasks requiring coordination of or coordinated activities between crew members, the arrangement and function are different. The trainees are organized into pairs. One member assumes the role of pilot while the second assumes that of the observer or copilot/gunner. Each trainee station is suitably configured for the aircraft type(s) involved. Early training deals with procedures; later training involves coordinated activity and problem solving. All are accomplished in the same synthetic trainer.

In team training, the same arrangement is used but with some modifications. Two or more groups of trainees are involved--a scout and an attack group. Each crew works in a station configured for their aircraft and their role. Headphones or links through the CRTs enable communication between crew members and team members.

Deviation of ITTS from High Fidelity Simulation

The ITTS is not a high fidelity simulator. Such lack of high fidelity possesses cost advantages. Additionally, high realism in the training situation does not guarantee success on the actual flight task.

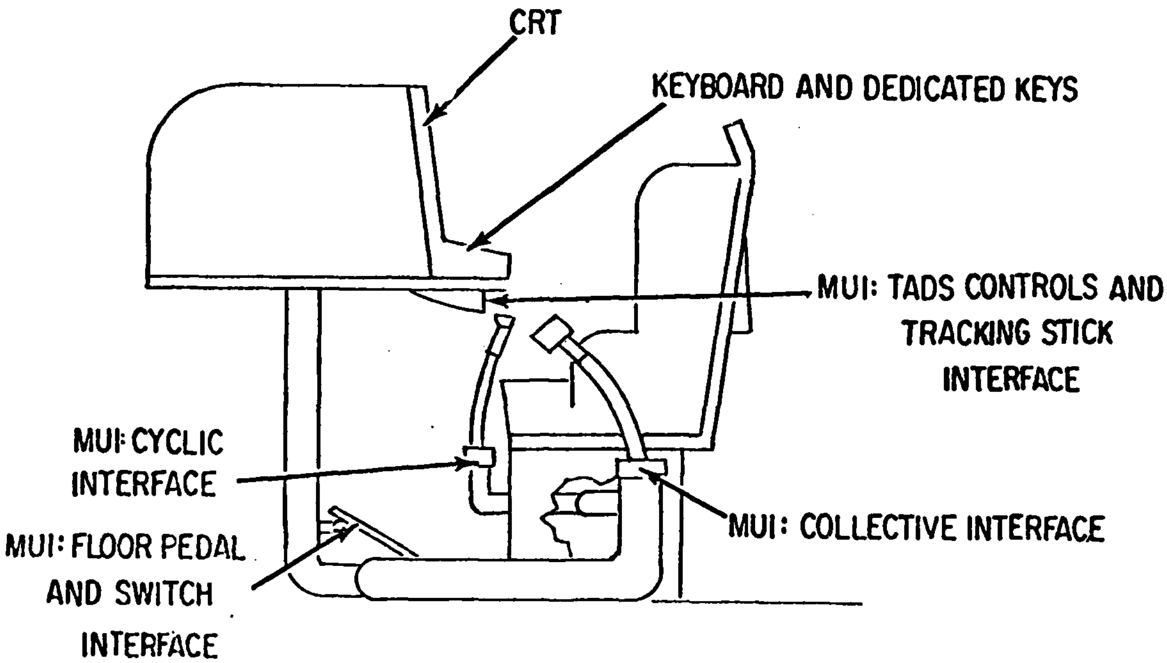

Figure 4 Individual trainee station showing modular unit interfaces (MUI).

There is not always a high correlation between the degree of realism and the effectiveness of a training system. Intentional deviations from realism may even improve the effectiveness of a training system.

Adequacy of the ITTS

The ITTS concept was subjected to a systematic analysis to determine, in the assessors' (two human factors engineers and a scout helicopter pilot) judgments, the adequacy of the system. To this end, the perceived ability of the system to train all of the tasks subsumed by each helicopter function was analyzed. All of the judgments were assessments of the relationship between the system, the subtasks to be trained, and the various components of adequacy examined.

Adequacy was examined in terms of:

- scope - can the various training requirements be met using the system?
- training objectives - what percentage of each training objective can be expected to be achieved using the system?
- familiarization - is the system adequate for familiarizing the trainees with performance and system limits?
- understanding - does the system adequately enable trainees to understand the tasks, the techniques of system use, and the concepts governing their use?
- problem solving - what is the system's adequacy in the critical area of identifying problems and selecting optimum solutions?

Separate analyses were performed for the AHIP, the AH-64, and the AH-1S(MC).

The analyses indicated that:

- the system can be anticipated to allow performance criterion attainment for about 80 percent of the set of the transition training requirements
- the strengths of the ITTS system come mainly from its support of more cognitive areas of flight, such as understanding implications and problem solving

III. DISCUSSION

The aircrew training community has become very sensitive to accidents linked to error in pilot judgment, (e.g., Brecke, 1982, Jensen, 1982). New forms of training have been suggested to foster the development of accurate, rapid decision making in complex, uncertain, and stressful situations in which time is a critical variable.

Similarly, the various analyses summarized earlier in this report repeatedly indicated the requirements for problem analysis and solution and/or crew/team coordination training if mission success is to be attained and crew member safety is to be maintained.

The problem solving and crew coordination emphasis also possesses direct implications for the selection and training of nonaviator observers. The observer training needs to be integrated with the pilot training for tasks requiring intracrew coordination and with attack crews for tasks requiring team coordination. Before crew or team training can be administered, the observers will require some individual training within a curriculum which contains various aviation concepts, e.g., navigation, principles of flight.

It may also be necessary to devise selection criteria other than those applicable to the Armor Reconnaissance Specialist MOS (MOS 19D10 or 19D20) from which observers are to be drawn. Perhaps, observer candidates should be at least partially screened on the basis of the Revised Flight Aptitude Selection Test or some variant of it to ensure aptitude for the aviation environment.

Intellective Load

Another approach to the problem of selecting persons who can perform complex problem solving in the time-sharing situation involves assessing the intellective load carrying capacity of the candidates. Intellective load carrying capacity is a multidimensional concept not directly related to "intelligence," as assessed in most "intelligence tests," or by the Armed Services Vocational Aptitude Battery (ASVAB). The intellective load carrying capacity concept is derived from information theory and a variety of information processing oriented theories (e.g., Broadbent, 1963), which suggest that individual channel capacity is a critical determinent of the adequacy of an individual's response to events and configurations.

Within the human factors field, there is a dearth of data on the effects of intellective channel capacity on performance. Few studies have attempted to assess the effects of increasing intellective loads on an operator's ability to use properly a system or perform perceptual-motor tasks.

Siegel and Cosentino (1971) noted that a need exists for a technique which will enable measurement of the intellective load which a given system operator can manage. Within such a technique, it must be possible to vary the intellective load on the operator in a known, controlled, quantifiable manner, while the perceptual-motor load is held constant. Moreover, the task material must be based on and drawn from a sound concept of intellective structure. Finally, the technique must allow precise statement of the effect, if any, of intellective overload on the operator's performance. Such a technique would enable answers to questions such as:

- At what intellective load level does this operator's motor performance start to deteriorate?
- What is the effect of various types of intellective loading on this operator's performance?
- Can this operator manage a higher load for one type of intellective task than for a second type of intellective task?
- What type of information presented to the operator causes the earliest overload?
- Does presenting the same information, in a different manner, produce less of an intellective load on the operator?
- Where in the operator's task sequence does the least intellective load occur?
- How can the intellective load on the operator be lightened?

The method, developed by Siegel and Cosentino (1971), is based on simultaneous performance of a Thurstone scaled set of intellective tasks and a pursuit tracking task. The point on the intellective scale at which the transfer function changes is assumed to represent the intellective load carrying capacity of the subject. The Siegel and Cosentino scales for the intellective load measurements were based on Guilford's (1967) Structure-of-Intellect model of human intellectual function. Intellective functions relevant to the astronaut tasks were identified and twelve cells of the model's 120 were selected as representative of the mental operations performed most frequently by astronauts.

A set of test items, designed to represent increasing mental load, ranging from easy to difficult, was developed and validated for each cell. Accordingly, each item could be represented along a scale of intellective load.

The pursuit tracking task provided the baseline against which the effects of intellective load could be measured. The tracking target was generated as a function of the sum of four sine waves. It was assumed that within clearly defined limits, tracking is a direct function of the target's input frequencies. Siegel and Cosentino (1971) anticipated that if input signal frequency is held constant, deterioration of amplitude ratio and of phase lag will occur when the intellective load of Guilford defined intellective items reaches elevated difficulty levels as defined by the underlying Thurstone scale of difficulty. The point of deterioration, as indicated by a transfer function change, was taken as indicating the "threshold" of the operator.

The method was tested by Siegel and Williams (1973) who concluded that: the intellective load carrying threshold concept possesses merit, intellective load carrying ability seems to be measurable, and thresholds vary within individuals and across intellective functions as well as across individuals within functions.

The technique seems to represent a useful method for assessing individual differences in intellective load carrying capacity in helicopter crew members and seems to merit consideration for use in this regard.

Other Implications

The major emphasis throughout this report was on the derivation of transition training requirements and methods with secondary emphasis on an Integrated Transition Trainer concept and tertiary emphasis on selection. However, this emphasis is not meant to diminish the need for flight training, refresher training, and advanced training in squadrons and elsewhere. Because the transition training will provide realistic, mission oriented learning and proficiency development, it will allow the helicopter crews and teams to enter into and proceed more rapidly in unit training but by no means can it be expected to substitute for that training.

Similarly, depending on the design of the transition trainer, a need may still exist for a limited number of part task trainers. Use of the mast mounted sight in the AHIP and use of night vision devices may represent examples of areas which might profit from part task trainers or specially designed training situations.

Communication content training represents another area in which pay off can be anticipated both in terms of mission success and promulgation of flight safety. The various analyses indicated a need for coordination (communication) both within crews and within and across teams. Improved communication can be conceived as a force multiplier in much the same way as command and control can be conceived as force multipliers. The emphasis here is on the content of communications and not on how to work various communication devices.

What suggestions should be made? What should be the content of such suggestions? When should information be provided? What information? When and what kind of information should be requested? From whom and how often? Helicopter research in the Navy (Siegel and Federman, 1968) has indicated that "successful" and "unsuccessful" antisubmarine warfare helicopter attacks can be differentiated on the basis of the communication content during the attacks. It seems reasonable to expect that the same result will hold for Army helicopter attack teams.

Finally, although the present report placed its emphasis on training requirements and methods, the need for proper selection--especially in regard to observers, but also for pilots--was suggested. Accordingly, some emphasis was placed on assessing the ability of crew members to process intellective loads while simultaneously performing collateral tasks. It seems that proper and improved selection, coupled with training that meets helicopter training requirements, can advance the capability of the man-equipment integrals considered throughout this report.

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APPENDIX A

Mission Profiles

NTSH/AH-64 Attack Mission: engage predesignated target; VMC; day/night mission; total distance = 68km; flight time = 97min

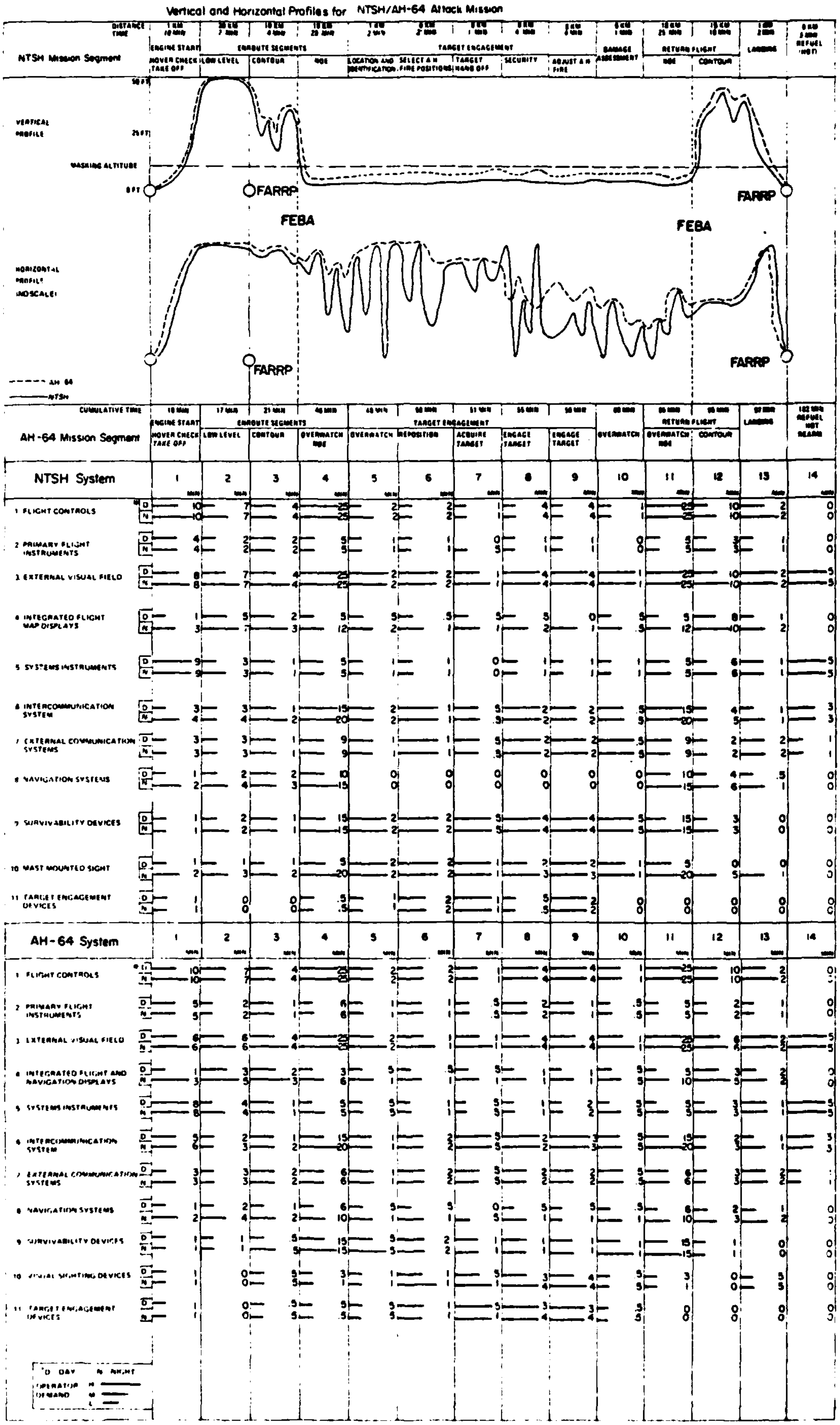

Figure A-1. Mission analysis results for AHIP/AH-64 attack mission.

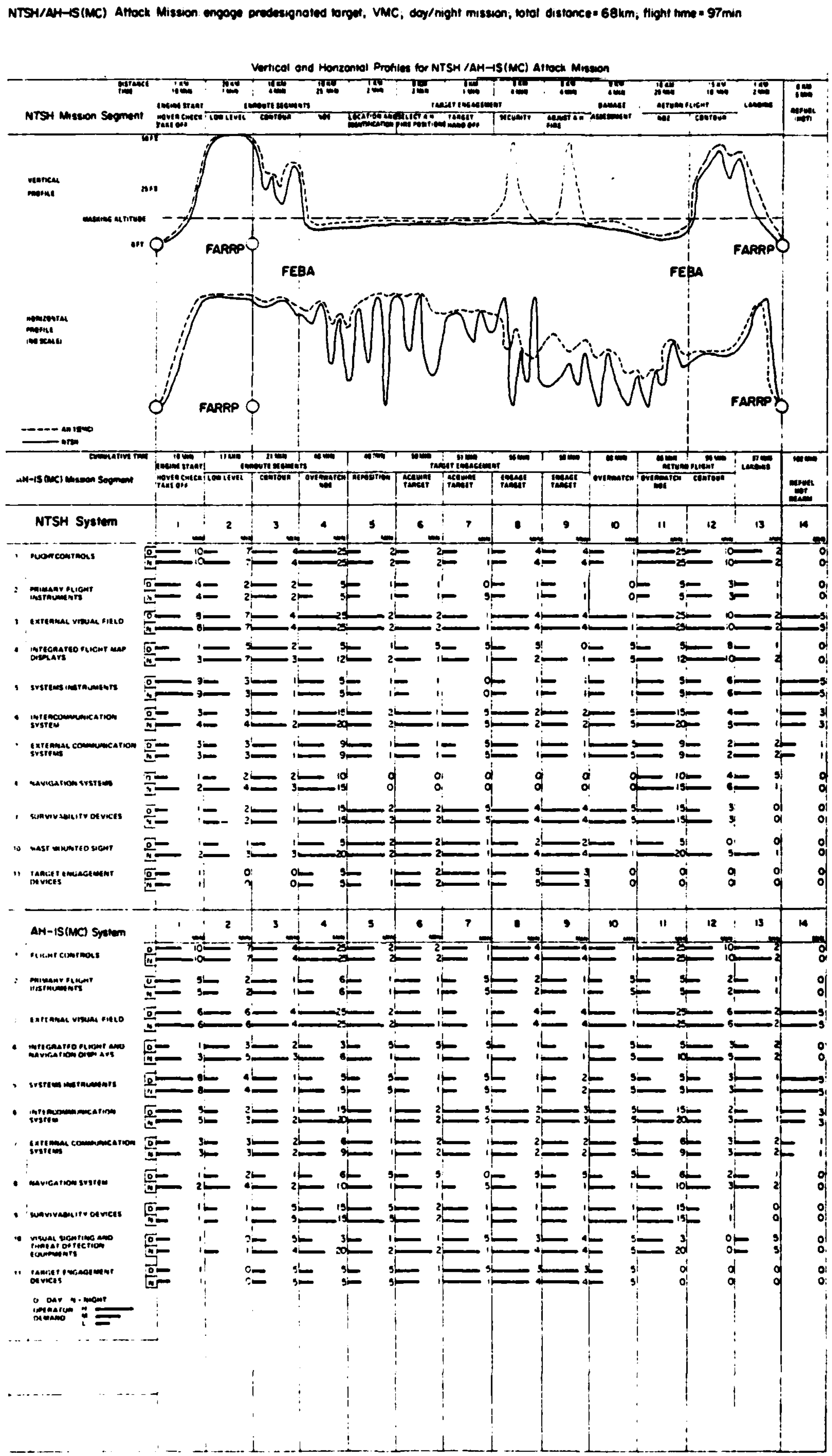

Figure A-2. Mission analysis results for AHIP/AH-1S(MC) engage predesignated target mission.

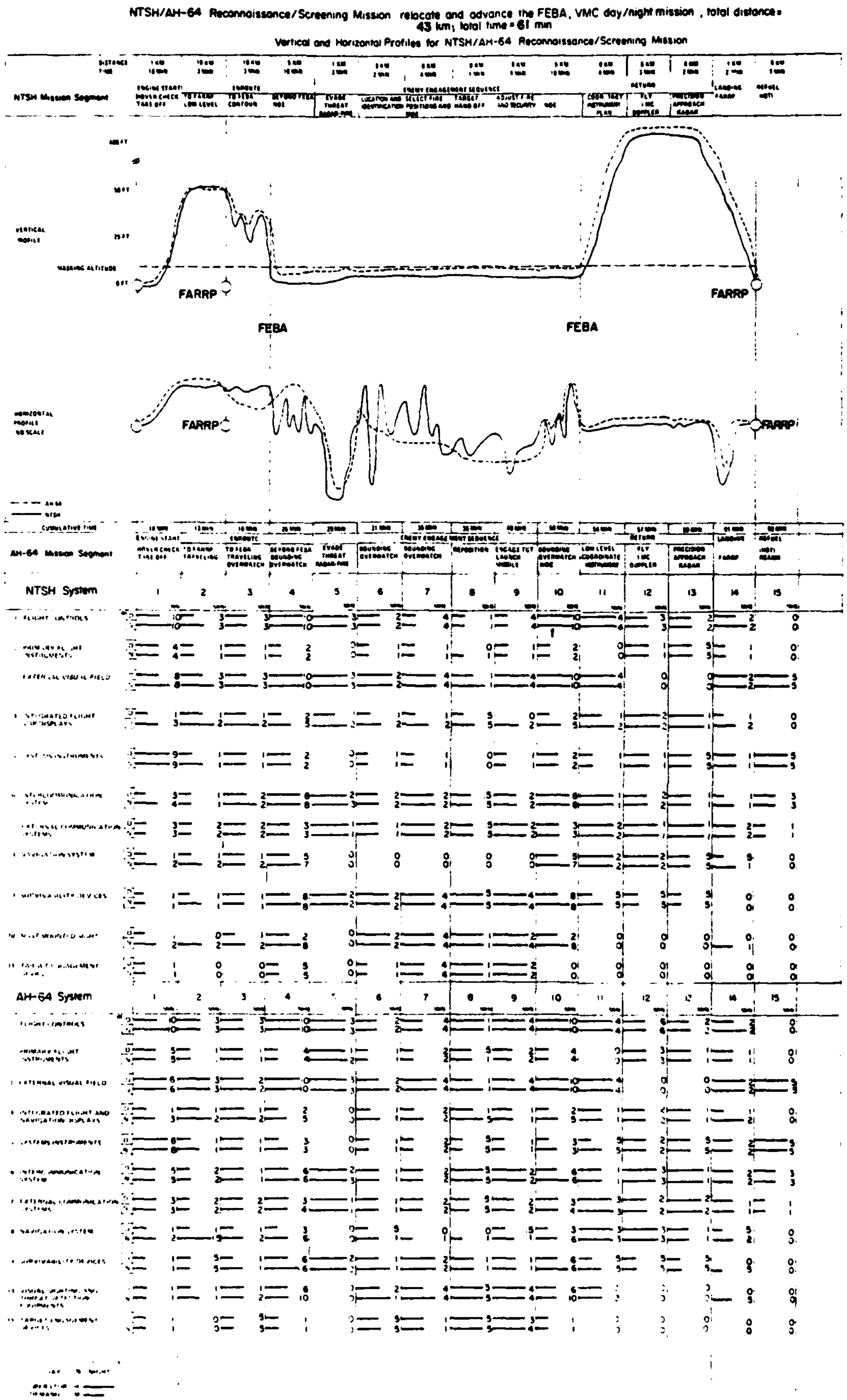

Figure A-3. Mission analysis results for AHIP/AH-64 reconnaissance screening mission.

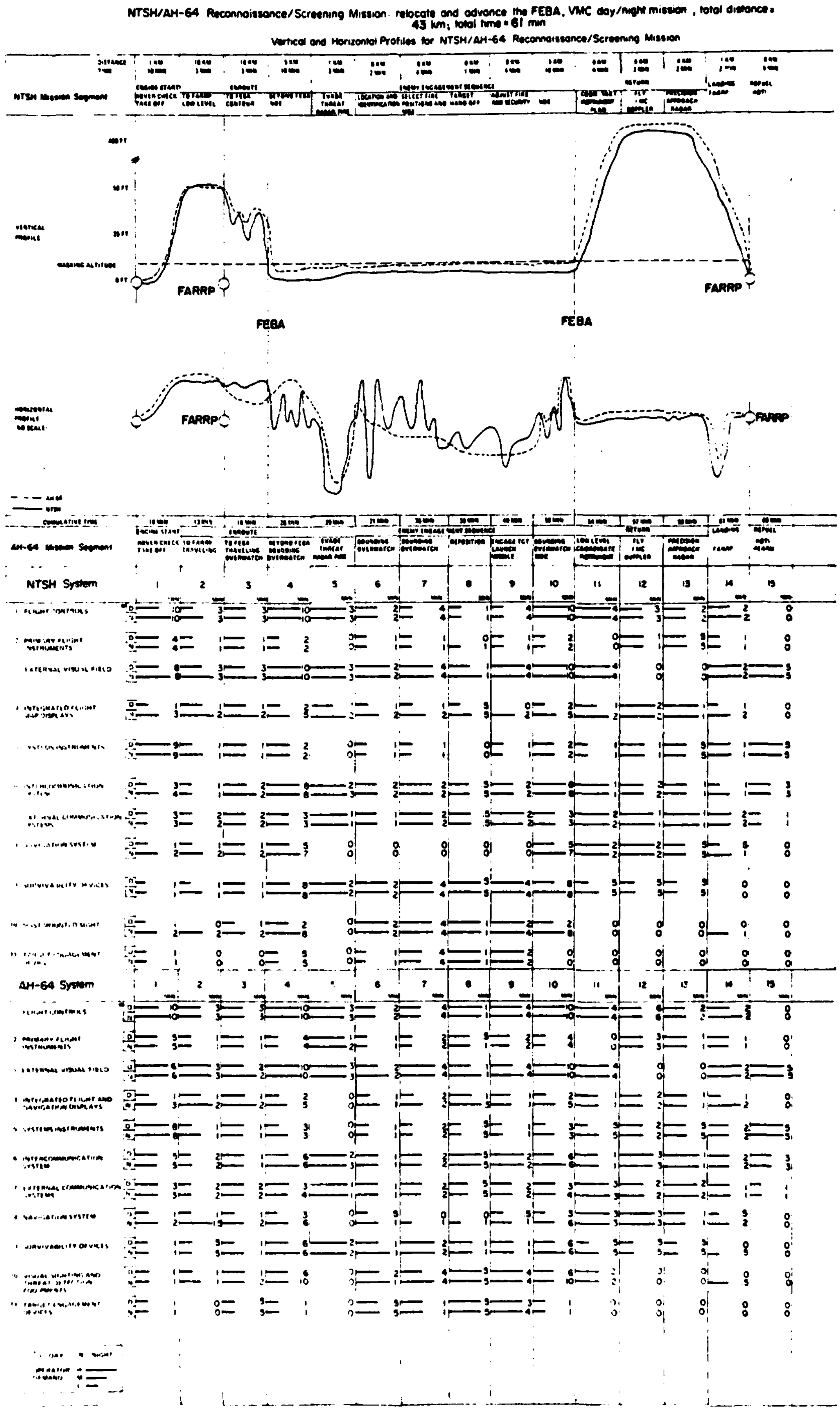

Figure A-4. Mission analysis results for AHIP/AH-1S(MC) reconnaissance screening mission.

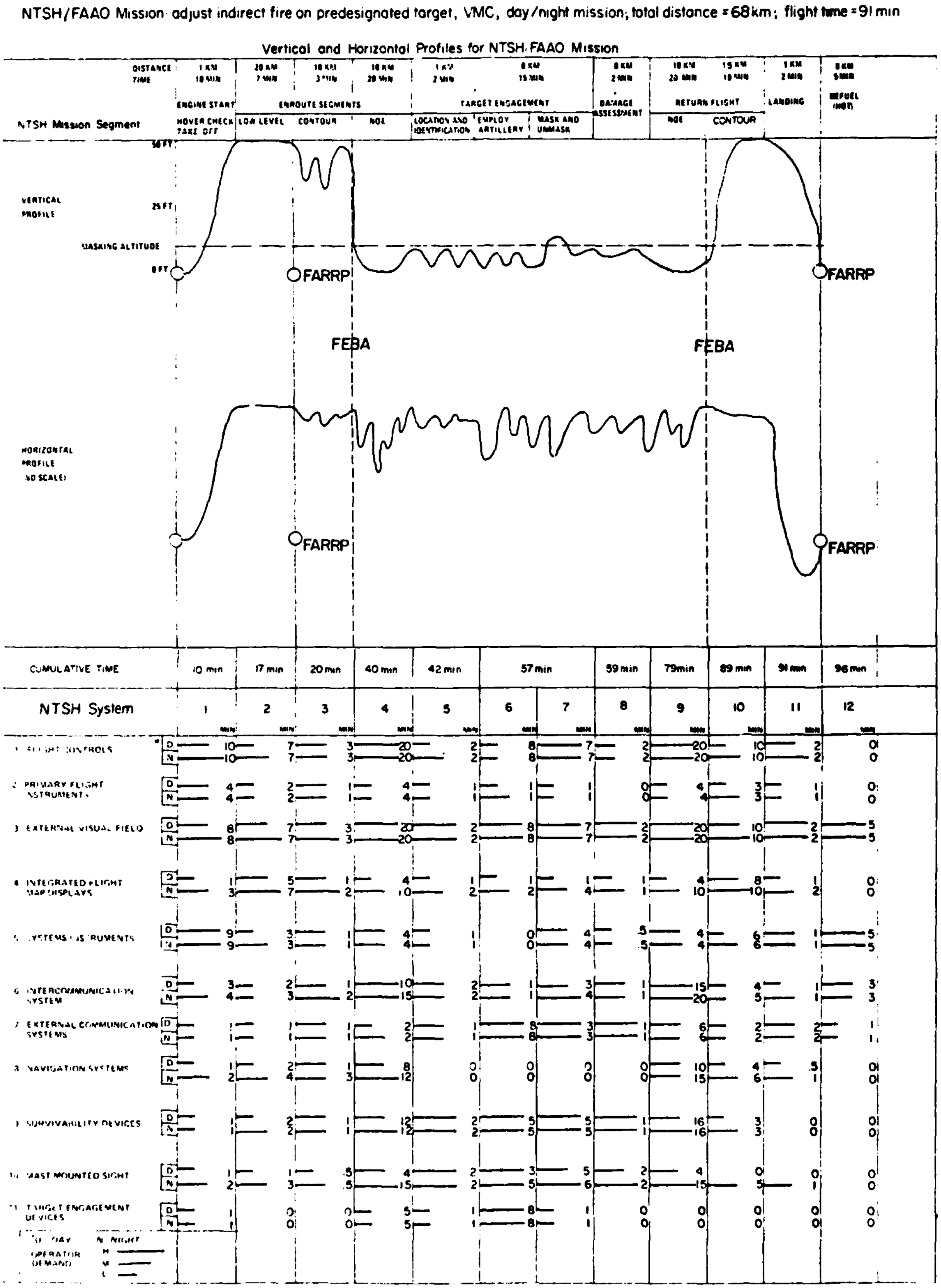

Figure A-5. Mission analysis results for AHIP/FAAO mission.

APPENDIX B

Example of Results of Time Series Analyses

Visibility Condition: D-N VMC Phase: Target Servicing Summary No.: 3.1.a.1 Aircraft: AH-64

Flight Condition: NOE/CONTOUR Segment: Target Acquisition: Recorded Automatic, Point Target Page 1 of 7 Pages

Systems	Location	Operator-Equipment Functional Interaction	Performed by	Operator Activity	Information Type	D/N	Load: Mental Amt	Load: Mental Diff	Load: Motor Amt	Load: Motor Diff	Delay Tolerance	Task Criticality	Comments
1. Flight Controls						D							NOTE: Cannot acquire target while masked
						N							
a. Collective	B	Maintain obstacle clearance	P	M	QA	D	5	4	4	4	5	5	Sequence
						N	5	5	5	5	5	5	1. Enable waypoint target acquisition
b. Cyclic	B	Control direction and airspeed	P	M	QA	D	5	5	4	4	5	5	a. set sight select to TADS (FCP)
						N	5	6	5	5	5	5	b. set acquisition select to TRGT
c. DASE Control Panel	P					D							2. Call up stored waypoint target coordinate
						N							
d. Pedals	B	Control trim	P	M	QA	D	3	4	4	4	4	5	a. set DEK control to TRGT
						N	4	4	4	4	4	5	b. enter index storage number
2. Primary Flight Instruments						D							
						N							
a. Accelerometer	P					D							3. Slave TADS to FCC
						N							a. press UPDT button
b. Airspeed Indicator	B					D							b. press slave on left handgrip
						N							
c. Attitude Indicator	B					D							
						N							

Figure B-1. An example of the results of the time series analysis.

Visibility Condition: D-N VMC   Phase: Target Servicing   Summary No.: 3.1.a.1   Aircraft: AH-64

Flight Condition: NOE/CONTOUR   Segment: Target Acquisition: Recorded Automatic, Point Target   Page 2 of 7 Pages

Systems	Location	Operator-Equipment Functional Interaction	Performed by	Operator Activity	Information Type	D/N	Load Mental Amt	Load Mental Diff	Load Motor Amt	Load Motor Diff	Delay Tolerance	Task Criticality	Comments
d. Barometric Altimeter	B					D							
						N							4. Make visual survey of TADS display, make small adjustments as required
e. Instantaneous Vertical Speed	B					D							
						N							
f. Standby Compass	P					D							5. When detected, center target on reticle and set IAT (CP-G's left handgrip)
						N							
g. Radar Altimeter Display	B					D							
						N							
h. Master Caution and Warning Panel	B	Monitor	B	V	CK	D	2	2	2	2	3	3	
						N	2	2	2	2	3	3	
i. Advisory Caution and Warning Panel	B					D							
						N							
3. External Visual Field	B	Monitor surroundings,	B	V, M	QA	D	4	5	4	4	5	5	
		and flight path			CK	N	6	6	5	5	5	5	
4. Integrated Flight/Navigation Displays						D							
						N							
a. Electronic Attitude Director Indicator						D							
						N							
b. Horizontal Situation Indicator	P					D							
						N							

Figure B-1. (cont.)

Visibility Condition: D-N VMC   Phase: Target Servicing   Summary No.: 3.1.a.1   Aircraft: AH-64

Flight Condition: NOE/CONTOUR   Segment: Target Acquisition: Recorded Automatic, Point Target   Page 3 of 7 Pages

Systems	Location	Operator-Equipment Functional Interaction	Performed by	Operator Activity	Information Type	D/N	Load Mental Amt	Load Mental Diff	Load Motor Amt	Load Motor Diff	Delay Tolerance	Task Criticality	Comments
c. Radio Magnetic Indicator	C					D							
						N							
5. Systems Instruments						D							
						N							
a. Emergency Hydraulic Pressure Gauge	P					D							
						N							
b. Fuel Control Panel	B	Check limits	P	V	QA	D	3	2	2	2	3	3	
						N	3	2	2	2	3	3	
c. Fuel Quantity Indicator	B	Check limits	P	V	QA	D	3	2	2	2	3	3	
						N	3	2	2	2	3	3	
d. Gas Generator Turbine Speed Indicator	P	Check limits	P	V	QA	D	3	2	2	2	3	3	
						N	3	2	2	2	3	3	
e. Oil Pressure Indicator	P	Check limits	P	V	QA	D	3	2	2	2	3	3	
						N	3	2	2	2	3	3	
f. Oil Temperature Indicator	P	Check limits	P	V	QA	D	3	2	2	2	3	3	
						N	3	2	2	2	3	3	
g. Power Turbine and Main Rotor Speed Indicator	B	Check limits	P	V	QA	D	3	2	2	2	3	3	
						N	3	2	2	2	3	3	
h. Torque Indicator	B	Check limits	P	V	QA	D	3	2	2	2	3	3	
						N	3	2	2	2	3	3	

Figure B-1. (cont.)

Visibility Condition: D-N VMC Phase: Target Servicing Summary No.: 3.1.a.1 Aircraft: AH-64

Flight Condition: NOE/CONTOUR Segment: Target Acquisition: Recorded Automatic, Point Target Page 4 of 7 Pages

Systems	Location	Operator-Equipment Functional Interaction	Performed by	Operator Activity	Information Type	D/N	Load: Mental Amt	Load: Mental Diff	Load: Motor Amt	Load: Motor Diff	Delay Tolerance	Task Criticality	Comments
i. Turbine Gas Temperature Indicator	P	Check limits	P	V	QA	D	3	2	2	2	3	3	
						N	3	2	2	2	3	3	
j. Selectable Digital Display	C					D							
						N							
6. Intercommunication System						D							
						N							
a. ICS Switch	B	Press to talk--ICS	B	M	QA	D	2	2	3	2	3	4	
						N	2	2	3	2	3	4	
b. Microphone	B	Coordinate aircraft position	B	S	QA, QT	D	5	3	4	2	4	4	
		to service target				N	6	4	4	2	4	4	
c. Earphone	B	Monitor ICS	B	A	QA, QT	D	4	3	4	3	4	4	
					CK	N	5	3	4	3	4	4	
7. External Communication Systems						D							
						N							
a. Communication Control Panel	B					D							
						N							
b. Radio/ICS Rocker Switch	B					D							
						N							
c. Remote/Transmitter Selection Switch	P					D							
						N							

Figure B-1. (cont.)

Visibility Condition: D-N VMC   Phase: Target Servicing   Summary No.: 3.1.a.1   Aircraft: AH-64

Flight Condition: NOE/CONTOUR   Segment: Target Acquisition: Recorded Automatic, Point Target   Page 5 of 7 Pages

Systems	Location	Operator-Equipment Functional Interaction	Performed by	Operator Activity	Information Type	D/N	Load Mental Amt	Load Mental Diff	Load Motor Amt	Load Motor Diff	Delay Tolerance	Task Criticality	Comments
d. UHF/AM Radio	P	Monitor air-to-air	P	M, A	QA, CK	D	3	4	4	2	3	3	
						N	3	4	4	2	3	3	
e. VHF/AM/FM Radio/Homing #1	P	Monitors FM, TR with	P	M, A	QA, CK	D	3	4	4	2	2	2	
		ground				N	3	4	4	2	2	2	
f. VHF/AM/FM Radio #2	C					D							
						N							
g. Voice Security UHF/AM	C					D							
						N							
h. Voice Security VHF/FM	P					D							
						N							
i. IFF Transponder	P					D							
						N							
8. Navigation System						D							
						N							
a. Direction Finder Controls	P					D							
						N							
b. Doppler Navigation Control Panel	C	Monitor heading and course	C	V	QA	D	4	4	4	2	3	3	
		deviation				N	4	4	4	2	3	3	
c. Electronic Attitude Director Controls						D							
						N							

Figure B-1. (cont.)

Visibility Condition: D-N VMC   Phase: Target Servicing   Summary No.: 3.1.a.1   Aircraft: AH-64

Flight Condition: NOE/CONTOUR   Segment: Target Acquisition: Recorded Automatic, Point Target

Systems	Location	Operator-Equipment Functional Interaction	Performed by	Operator Activity	Information Type	D/N	Load Mental Amt	Load Mental Diff	Load Motor Amt	Load Motor Diff	Delay Tolerance	Task Criticality	Comments
d. Horizontal Situation Control Panel	P					D							
						N							
e. Heading/Attitude Reference Control	P					D							
						N							
f. Radar Altimeter Control	B					D							
						N							
9. Survivability Devices						D							
						N							
a. Radar/IR Countermeasure Control	P					D							
						N							
b. Radar Warning Display	P	Monitor	P	V	CK	D	3	3	3	2	3	3	
						N	3	3	3	2	3	3	
c. Radar Warning Control	P					D							
						N							
10. Visual Sighting and Threat Detection Equipment						D							
						N							
a. Integrated Helmet and Display Sight System	B	Monitor symbology and	P	M, V	QA, QT	D	4	4	4	4	3	3	Night--PNVS
		sensor display			CK	N	6	6	5	5	5	5	
b. Heads Out Display	C					D							
						N							

Figure B-1. (cont.)

Visibility Condition: D-N VMC Phase: Target Servicing Summary No.: 3.1.a.1 Aircraft: AH-64

Flight Condition: NOE/CONTOUR Segment: Target Acquisition: Recorded Automatic, Point Target Page 7 of 7 Pages

Systems	Location	Operator-Equipment Functional Interaction	Performed by	Operator Activity	Information Type	D/N	Load: Mental Amt	Load: Mental Diff	Load: Motor Amt	Load: Motor Diff	Delay Tolerance	Task Criticality	Comments
c. Heads Down Display	C	Search for target	C	M, V	QA	D	4	4	4	3	4	4	
					CK	N	5	5	5	4	4	4	
11. Target Engagement Devices						D							
						N							
a. Collective Switch Box	B					D							
						N							
b. Data Entry Keyboard	C	Recall waypoint target-set to TRGT and enter storage location	C	M	QA, QT	D	4	3	3	2	3	3	
						N	4	3	3	2	3	3	
c. Digital Message Devices	B					D							
						N							
d. Fire Control Panel	B	Select sight and acquisition modes	C	M, V	QA, QT	D	3	2	3	2	3	3	
						N	3	2	3	2	3	3	
e. Handgrip Left	C	Adjust FOV, press UPDT and set IAT	C	M, V	QA, QT	D	3	2	3	2	2	3	
						N	3	2	3	2	2	3	
f. Handgrip Right	C	Slave TADS to waypoint target, adjust line of sight, if needed	C	M	QA	D	3	3	2	2	3	3	
						N	3	3	2	2	3	3	
g. Missile Control Panel	B					D							
						N							
h. Rocket Control Panel	B					D							
						N							

Figure B-1. (cont.)

APPENDIX C

Highly Scaled Intellective Categories for Crew-
members in Each Helicopter Type

Table C-1

Most Highly Scaled Intellective Categories
Involved in Functions of AHIP Helicopter Pilots

Function	Intellective Category	Load
1. Control flight with cyclic, collective, pedals	Cognition of figural relations	5.2
	Cognition of symbolic units	6.0
	Cognition of symbolic classes	6.0
3. Environmental orientation	Cognition of figural classes	12*
	Evaluation of figural relations	16
	Evaluation of figural classes	8.5*
	Cognition of figural relations	8.5*
4. Use pilot's multi-function/displays controls	Cognition of symbolic units	3.3
	Evaluation of symbolic classes	2.4
	Evaluation of symbolic relations	2.6
5. Use CPO's multi-function displays/controls/maps	Evaluation of symbolic implications	8.0
	Evaluation of figural relations	3.0
	Cognition of symbolic classes	6.0
7. Intracrew communication	Evaluation of figural classes	15.0
	Convergent production of symbolic units	12.0
	Convergent production of symbolic implications	12.0
	Convergent production of figural implications	12.0
8. External communication	Memory of semantic classes	3.5
	Memory of semantic units	6.0
9. Uses survivability devices	Cognition of figural classes	12.0
	Convergent production of symbolic relations	6.0
	Cognition of symbolic classes	3.0
	Convergent production of symbolic implications	3.0
11. Use MLMS controls	Evaluation of symbolic classes	12.0
	Cognition of symbolic classes	2.0
	Cognition of figural classes	4.0

*Poor visibility data

Table C-2

Most Highly Scaled Intellective Categories
Involved in Functions of AHIP Helicopter Observers

Function	Intellective Category	Load
2. Read/monitor secondary flight instruments	Convergent production of symbolic classes	5.25
	Evaluation of symbolic classes	5.25
3. Environmental orientation	Evaluation of symbolic classes	12.0*
	Evaluation of figural classes	12.0*
	Evaluation of symbolic transformations	12.0*
	Cognition of figural classes	12.0*
	Convergent production of figural transformations	12.0*
5. Use CPO's multi-functional displays, controls, maps	Evaluation of figural classes	12.3
	Convergent production of symbolic units	12.0
	Evaluation of symbolic units	9.5
6. Monitor/read system instruments	Cognition of symbolic units	4.0
	Evaluation of symbolic classes	3.7
	Evaluation of symbolic relations	1.9
7. Intracrew communication	Convergent production of symbolic implications	12.3
	Cognition of symbolic relations	12.0
	Evaluation of figural units	12.0
	Evaluation of semantic classes	12.0
8. External communication	Evaluation of figural relations	12.0
	Evaluation of semantic units	12.0
	Convergent production of symbolic implications	10.1

*Poor visibility data

Table C-3

Most Highly Scaled Intellective Categories
Involved in Functions of AH-64 Helicopter Pilots

Function	Intellective Category	Load
1. Control flight with cyclic, collective , pedals	Evaluation of symbolic relations	9.0
	Cognition of symbolic classes	6.0
	Cognition of figural relations	4.7
2. Read/monitor flight, caution & warning instruments	Cognition of symbolic units	4.0
	Evaluation of symbolic classes	2.9
	Evaluation of symbolic relations	2.0
3. Environmental orientation	Evaluation of figural relations	16.0
	Cognition of figural classes	12.7*
	Convergent production of figural classes	13.0*
4. Use integrated flight, navigation displays/maps	Cognition of symbolic units	4.7
	Evaluation of symbolic relations	3.5
	Evaluation of symbolic classes	2.8
5. Monitor/read systems instruments	Cognition of symbolic units	4.0
	Evaluation of symbolic classes	2.9
	Evaluation of symbolic relations	2.0
6. Intracrew communication	Evaluation of figural classes	16.0
	Convergent production of symbolic implications	13.3
	Cognition of figural classes	12.0
	Convergent production of figural implications	12.0
7. External communication	Cognition of semantic classes	6.0
	Convergent production of semantic classes	6.0
	Evaluation of symbolic units	6.0
8. Use navigation system to fly a course	Memory of symbolic units	12.0
	Cognition of symbolic relations	10.0
	Memory of semantic units	9.0
9. Use survivability devices	Cognition of figural classes	12.0
	Convergent production of symbolic relations	6.0
	Cognition of symbolic classes	3.0
	Convergent production of symbolic implications	3.0

Table C-3 (cont.)

Function	Intellective Category	Load
10. Use TADS/PNVS displays for threat identification	Cognition of symbolic units	4.0
	Evaluation of figural classes	2.0
	Evaluation of symbolic classes	2.0
	Evaluation of symbolic relations	2.0
	Evaluation of symbolic implications	2.0
11. Use devices & controls to select/ engage target	Evaluation of symbolic classes	12.0
	Evaluation of figural relations	12.0
	Convergent production of symbolic implications	8.0

*Poor visibility data

Table C-4

Most Highly Scaled Intellective Categories
Involved in Functions of AH-64 Helicopter Copilots

Function	Intelligence Category	Load
2. Read/monitor flight caution & warning instruments	Cognition of symbolic units	4.0
	Evaluation of symbolic classes	2.0
	Evaluation of symbolic relations	2.0
3. Environmental orientation	Evaluation of symbolic classes	12.0*
	Evaluation of figural classes	12.0*
	Convergent production of figural transformations	12.0*
4. Use integrated flight navigation displays, maps	Cognition of symbolic units	4.0
	Evaluation of symbolic classes	3.0
	Evaluation of symbolic relations	3.0
5. Monitor/read systems instruments	Cognition of symbolic units	5.4
	Evaluation of symbolic relations	3.4
	Evaluation of symbolic classes	2.9
6. Intracrew communication	Cognition of semantic classes	16.0
	Convergent production of symbolic implications	12.3
	Cognition of symbolic relations	12.0
	Evaluation of symbolic relations	12.0
	Evaluation of semantic classes	12.0
7. External communication	Convergent production of symbolic classes	16.0
	Convergent production of semantic implications	8.0
	Cognition of symbolic classes	8.0
8. Use navigation system to fly a course	Cognition of symbolic relations	12.0
	Convergent production of symbolic transformations	12.0
	Evaluation of symbolic implications	10.0
10. Use TADS/PNVS displays	Convergent production of symbolic units	12.0
	Evaluation of figural classes	9.0
	Evaluation of figural relations	9.0
	Evaluation of symbolic transformations	9.0
11. Use devices & controls to select/engage target	Evaluation of figural classes	12.0
	Evaluation of symbolic classes	12.0
	Cognition of figural classes	12.0

*Poor visibility data

Table C-5

Most Highly Scaled Intellective Categories
Involved in Functions of AH-1S Helicopter Pilots

Function	Intellective Category	Load
1. Control flight with cyclic, collective, pedals	Evaluation of symbolic relations	9.0
	Cognition of figural relations	10.5*
	Cognition of figural relations	4.7
2. Read/monitor primary flight instruments	Evaluation of symbolic relations	2.0
	Evaluation of symbolic classes	2.0
	Cognition of symbolic units	4.0
3. Environmental orientation	Evaluation of figural relations	12.0*
	Evaluation of symbolic transformations	12.0*
	Convergent production of figural classes	12.0*
4. Use integrated flight/navigation displays/maps	Cognition of symbolic units	4.6
	Evaluation of symbolic classes	3.2
	Evaluation of symbolic relations	3.25
5. Read/monitor caution, warning & systems instruments	Cognition of symbolic units	5.3
	Evaluation of symbolic classes	3.6
	Evaluation of symbolic relations	3.3
6. Intracrew communications	Convergent production of figural implications	25.0*
	Evaluation of figural classes	20.33*
	Cognition of figural classes	18.0*
7. External communication	Cognition of semantic classes	6.0
	Convergent production of semantic classes	6.0
	Evaluation of semantic classes	4.5
8. Use navigation system to fly a course	Evaluation of symbolic units	7.5
	Convergent production of symbolic implications	6.5
	Cognition of symbolic classes	6.0
	Memory of symbolic classes	6.0
	Evaluation of symbolic classes	6.0
9. Use survivability devices	Cognition of figural classes	20.0*
	Convergent production of symbolic units	16.0
	Cognition of figural classes	12.0

Table C-5 (cont.)

Function	Intellective Category	Load
10. Use visual sighting devices for threat	Evaluation of figural classes	25.0*
	Evaluation of symbolic classes	15.0
	Evaluation of figural classes	12.0
11. Use controls & devices to sense, engage target	Evaluation of symbolic relations	25.0*
	Evaluation of symbolic relations	16.0
	Evaluation of symbolic classes	16.0

*Poor visibility data

Table C-6

Most Highly Scaled Intellective Categories
Involved in Functions of AH-1S Helicopter Copilots

Function	Intellective Category	Load
2. Read/monitor primary flight instruments	Evaluation of symbolic relations	2.0
	Evaluation of symbolic classes	2.0
	Cognition of symbolic units	4.0
3. Environmental orientation	Evaluation of figural classes	12.0*
	Evaluation of symbolic classes	14.0*
	Convergent production of figural transformations	12.0*
4. Use integrated flight/ navigation displays/ maps	Evaluation of symbolic relations	3.0
	Evaluation of symbolic classes	3.0
	Cognition of symbolic units	4.0
6. Intracrew communications	Convergent production of symbolic implications	20.0*
	Evaluation of semantic classes	19.0*
	Convergent production of symbolic classes	16.0*
	Evaluation of figural units	16.0*
	Cognition of semantic classes	16.0
7. External communication	Convergent production of symbolic classes	25.0*
	Convergent production of symbolic classes	16.0
	Evaluation of semantic classes	10.0
8. Use navigation system to fly a course	Evaluation of symbolic transformations	16.0*
	Convergent production of symbolic transformations	12.0
	Evaluation of symbolic implications	10.0
10. Use visual sighting devices for threat	Cognition of symbolic units	25.0*
	Evaluation of symbolic classes	25.0*
	Evaluation of figural classes	25.0*
11. Use controls & devices to sense, engage target	Evaluation of symbolic classes	16.0*
	Evaluation of symbolic classes	5.3
	Evaluation of figural classes	6.0

*Poor visibility data